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# Conference on Industrial Applications of Aerospace Research

Sponsored by

Aerospace Research Applications Center,  
Indiana University Foundation

in cooperation with

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CONFERENCE ON  
INDUSTRIAL APPLICATIONS OF AEROSPACE RESEARCH

Sponsored by  
Aerospace Research Applications Center  
Indiana University Foundation  
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STATEMENT  
ON  
AEROSPACE RESEARCH APPLICATIONS CENTER  
INDIANA UNIVERSITY

By  
Dr. Herman B Wells, President, Indiana University Foundation

January 10, 1963

I am pleased to welcome you to our meeting today. This meeting is designed to describe the nature and effort of the Aerospace Research Applications Center. It is hoped that information provided by the meeting will inspire some of you to become active partners in the project.

Some months ago the dynamic Director of the Space Administration, Mr. James E. Webb, asked us to come to see him. In the course of our visit he stated that he wished some university to undertake an experiment to discover ways to accelerate the spinoff from the space research effort.

He envisioned an experiment with a business school approach, solidly backed by the university basic science departments with engineering assistance where needed.

As a result of our discussion on the occasion of that visit, we were invited to submit a proposal and hence we meet today.

In sponsoring our experiment, Mr. Webb seeks to help realize a mandate of the congressional legislation creating NASA. In this legislation, the agency is specifically mandated to use the space research effort to promote the economic development of the nation, in addition to its specific technical objectives, such as the flight to the moon. The Act recognizes that new knowledge is the basis for new wealth. The country is fortunate to have Mr. Webb as administrator because he believes that space research can contribute enormously to economic growth, and he is determined to do all in his power to bring about this result. We are pleased to have here today two of his close associates who it will be my privilege to present to you later in the meeting. I know we shall be greatly benefited by their participation in our session.

Let us reflect for a moment on the nature of the present space research effort.

It is vast.

It is pervasive.

Its potentialities are beyond even our powers of imagination.

Never has there been a comparable research effort.

It is carried on in countless university laboratories, in industrial laboratories, and directly by NASA in special research installations of enormous size and complexity. The nature of the NASA objective requires a research

effort that covers the entire range of biological, natural, and physical science. Its effort is at once so vast and so exact that special control and management techniques have had to be developed and are now being tested in the crucible of experience.

Hence, the potentialities of this effort for our entire economy are beyond our present powers of comprehension.

We are willing to undertake the responsibilities of this experiment because we believe this is fertile ground for such an effort.

Indiana and the Midwest have been traditional centers of industry. We have industrial know-how and manpower, a great deal of it represented here this afternoon.

This region has been active in the past in R & D and is determined to be so in the future. Indiana and this region have always offered to industry transportation advantages which will be even more pronounced in the future with our new port on the north, improved river transportation on the south, the continuance of the freight services of our rail network, and finally a unique cross roads position in the new Interstate Highway system. I am convinced that this region's greatest industrial achievements are ahead, not behind us.

The project which we will outline today is frankly experimental. We seek to discover or develop new ways to speed up the industrial application of space research. As in all experiments, results cannot be assured. If we knew the results, the experiment would be unnecessary.

This experiment will be a three-way partnership involving NASA, Indiana University (specifically its School of Business and basic sciences and School of Medicine), and business and industry. For the first year we hope to limit industry participation to a manageable number of firms, with the expectation that the number may be increased substantially in succeeding years. A membership fee will be charged, because NASA believes, and we concur, that this is the best way to insure serious participation on the part of those joining the project.

We have attempted to invite all who might be interested to this initial meeting so that all might benefit from the discussion and have an equal chance to join.

We have included some utilities and financial institutions who are not directly in the R & D field, but have a keen interest in the welfare of their industrial customers of the region which they serve.

The contracting agency for the project is The Indiana University Foundation. The Foundation, the School of Business, and the entire University expect to give this project the strongest possible support.

Our industrial strength was developed out of the Industrial Revolution. We are in the midst of a new revolution, the scientific revolution, certain to profoundly change every aspect of industry and of our life. Our present effort gives us an opportunity to make our small contribution to directing the nature of that change.

## THE ROLES OF THE UNIVERSITY, INDUSTRY AND NASA IN RESEARCH APPLICATIONS

Colonel R. P. Young  
Executive Officer, Headquarters  
National Aeronautics and Space Administration

It is a great pleasure and I truly appreciate the opportunity that we have been afforded to participate here along with my colleague Mr. Fong and my associate Mr. Gadberry from the Midwest Research Institute, from whom you will hear later. My discussion deals with the impact the space program has had on American business and the role which the aerospace research center of the University here will play in spinning off the technology from the space effort into the private sector of our economy.

The National Aeronautics and Space Administration, which I am of course representing, along with my colleagues, is active in support of this Center. We believe that the leadership of this University represented by President Stahr, by Dr. Wells, by Dean Weimer and the other able people here, can accelerate and extend the benefits that will flow from the research and development that comes from this enormous space research program that this nation has under way.

We might say the Space Age began with the successful orbiting by the Soviet Union of Sputnik I in 1957. I am sure there were many reasons following that event that impelled the Congress of the United States to pass the Space Act of 1958 which put NASA into business as the space agency of the United States. I am sure that there were many reasons since then that have impelled the President and the Congress to authorize the investment of a very substantial part of our national resources in the programs that we are undertaking to create space power for the United States, in the same sense that we have had air power and sea power. And, I am sure that there are many reasons of various types why the general public, the American citizens, support the space program, although I am quite certain that the average citizen really doesn't appreciate the tremendous influence that this program is going to have upon our lives in the years ahead. As a matter of fact, you might liken the citizens with the man who was asked, "Do you believe in baptism?" And he replied, "Believe in it, man, I've seen it done." Well, certainly the citizens have seen it done in space. They have seen John Glenn and Carpenter and Shirra orbit and seen pictures of Telstar, the pictures that the communications satellite has rebroadcast, and they have seen pictures that came from the Tiros, the weather satellite. They have seen pictures of Mariner and know a lot about the flight by Venus. But, of course, you can't see everything in the space program. It is much deeper than that. Nor can you simply categorize the space program as a race to the moon against the Soviet Union.

The Administrator of NASA, Mr. Webb, has outlined four basic reasons underlying the space program. I'd like to take just a moment to go over these. The first is that man will explore space now that the rockets which permit this task have been developed. Once given the power to go beyond the earth's gravity, to do the exploration, man is going to do it, just as he has explored the earth. He is going to explore the universe. He is

going to explore space to the extent that it is practical, both manned and unmanned. It is certain that the United States is not going to settle for a second place in this exploration. This nation must and will insist upon being in the vanguard of this scientific adventure.

The second point I would make as an underlying reason relates to our tradition as a leader in technology. Shortly after we heard the first beep of that Sputnik in 1957, I think it was pretty clear that the United States could not ignore the challenge to lead in an important area of scientific research and development, and to be preeminent in this area of research, particularly in a field where for so long we had taken it for granted that we had the superiority.

The third underlying reason, of course, is that the interest of the national defense demands that we insure that space does not become an avenue of approach whereby an aggressor can successfully attack the United States.

The fourth reason given by Mr. Webb is the certainty that the basic scientific knowledge that this program will develop and the technology that will flow from it will offer great returns to this nation. History has taught us that although we cannot predict the benefits that will flow from basic scientific research it is certain that such research leads to many benefits undreamed of by the researcher.

The Congress of the United States in passing the Space Act of 1958 that established NASA wisely foresaw that in undertaking this enormous space effort we would be producing new products, new knowledge, new techniques, new processes. They didn't know what, but they knew that this would be happening and they wrote into the law that it was the responsibility of NASA to develop the results of this program to the benefit of all mankind. Now the point I wish to make here is that the effort we are making on behalf of the United States government in trying to feed back into the economy benefits of our research and development efforts is not an afterthought or a secondary effort. It is a primary effort--one of the basic objectives of our program--and we are giving a great deal of thought and effort to it. This is one of the reasons why we are here today.

We believe it is terribly important. We have dedicated ourselves to exploiting this effort to the maximum extent possible. A few moments ago Dr. Wells said that we are in a scientific revolution. I had intended to say that we are in an era of science and technology. This means the same thing, I believe. I don't think any of us question the fact that we are in this era. I don't know when it started. I'm not about to claim that it started with the beginning of the Space Age. But it is not important when it started. We are in it. How far in it, I don't know, but I feel that we are just across the threshold a little way. I think that we are far enough into this age to know and to realize that the manner in which we profit from it can be one of the most important single factors in our economic growth, in our national well being, and probably in the survival of our nation as a leader of the world. I say this seriously and thoughtfully and I believe many others feel this way.

We have reached a point in research and development where the individual inventor such as Henry Ford or Thomas Edison has largely been replaced by teams of highly skilled scientists and engineers. A technological and scientific break through now is frequently obtained by a highly organized

team effort backed up with a lot of money, a lot of equipment, buildings, and a complex organization. In many cases the effort is so great and so costly that only the federal government can undertake it.

We are learning how to organize very large scientific efforts in the federal government. We are spending today in the federal government about twelve billion dollars annually in what we call research and development. A few years ago we were spending just a few million. World War II brought a tremendous acceleration in the spending in R & D.

Following World War I, when the airplane in effect came of age, the federal government established NACA which was the forerunner of NASA and which we have absorbed in becoming NASA. The National Advisory Committee on Aeronautics was organized after World War I for the specific purpose of developing the building blocks, the technological building blocks, to make this nation supreme in the air. Our success in World War II in aircraft performance proved the viability of this approach and the success of that agency. You may never have heard of NACA but this scientific organization developed the building blocks for our successful performance in the air in World War II. A second example of the government getting into R & D on a very large scale was the Atomic Energy Commission, which was formed after the Second World War to exploit for military purposes and peaceful purposes the discoveries that we had made of the fission process and the fusion process. Here again, we had a major government organized effort.

And now, NASA, the space agency of which I am a member, has been organized for an even greater, more challenging, scientific task. We are learning how to organize to do highly demanding scientific and technological tasks. What we have not yet learned is how to extract from these tremendous efforts and all this money we are spending the most effective ways for feeding the benefits of these efforts back; that is, making available to the entrepreneur and the industrialist the new things we learn, the techniques, the new materials, etc. We haven't learned to feed this knowledge back into the private sector so that the entrepreneurs in business and industry can use them to profit, to benefit themselves and the national economy.

There may have been good reason why we haven't learned to do this. It is a relatively new area. Initially much of the information was classified. So perhaps there is some excuse for not having done more to date. But NASA is now in the fortunate position that practically everything we do is unclassified, and we are charged by Congress to disseminate that information as broadly as we can. We have this opportunity and we are going to make it succeed. We are going to find ways to achieve this feed back into the private sector to help make this economy grow.

The task we are discussing is a formidable one. You'd expect it to be so. For example, it is estimated in 1960 the national investment in research and development generated 60 million pages of technical reports--60 million pages--now that is equivalent to having enough pages every day to fill 24 volumes of the Encyclopedia Britannica seven times. By 1970 we expect that output will double. In the space activity alone in 1962, there were some 70,000 pages of technical reports. This doesn't include a great volume of unpublished information within NASA itself and within the contractors who work for us.

Now we are confronted by this mass of information. It has become obvious to us in NASA that the use and dissemination of this knowledge is



new and unique to government operation. Hence we are borrowing from the industrial and professional sectors of private life. NASA is utilizing the services of highly qualified industrial consultants in industrial management and research institutes, to devise means of insuring utilization of the space results. You are going to hear more about this in detail a little later from some of our other speakers. But I want to emphasize here, no matter what efforts we in the federal government make to supply the mechanism to bring out of this pool of information useful data for the entrepreneur, we're convinced that a direct relationship between government and industry can achieve only a small part of the potential benefits we seek. We believe that the breadth and complexity of the total scientific effort in which we are involved is so great that no one firm, no one industry, or group of firms can have the type of research staff required to keep up with the rapidly increasing knowledge and to adequately evaluate its potential for the economy. We do believe, on the other hand, that there must be an intermediate agency which acts as a transmission belt between the government and industry. And we believe that the natural agency, the natural middleman, for this operation is the university.

The university is the institution which can fulfill this role because it has interdisciplinary competence. It is the only institution which can understand the significance of the basic scientific discoveries and their potential for technological application. This is our concept. It's a new concept which creates a new role for the University, and a new relationship for the University and the industries in the region it serves.

This then is the major point I want to put across. We are talking of a new concept, a new method--not of changing the university but broadening the manner in which it serves a region--the way it looks at the region. Instead of looking inward toward educational programs alone, it looks outward toward the region it serves. There is no doubt in my mind or the minds of the administrator or others at NASA that this nation's educational and industrial resources can be brought together in an effective and viable relationship to tackle this problem--to facilitate the spin off from scientific advances with the University acting as the middleman, serving industry in the area where it is located.

What we are talking about is no easy task. This is a major change, I believe, which we have got to recognize. Nothing which has the broad impact of the subject we are talking about today will come easy. And anybody who participates with the University in this program, any industry, should not think in terms of something coming easy by perhaps applying a few thousand dollars to the program and then sitting back and watching what comes up. This, indeed, is a challenge to the leadership of this area, this region, and, indeed, all the regions in the United States.

I have had the privilege of working with communities in water resources development in my responsibilities when I was a district engineer for the Corps of Engineers. This is another type of development that requires regional leadership to look forward and have the foresight to be able to make investments today, the benefits from which may come some years hence. It was very clear to me that there were some communities in which I worked that had leadership, and they moved forward and their communities grew and prospered. And there were others that had narrow points of view and were looking for an immediate profit. They did not have the vision or the leadership ability to go forward. This is what we are talking about today--the character of the leadership of this area.

I am the first one to say that there's got to be something in it for you. You're in business. Your profit and loss statement determines whether you succeed or not. This is going to be the end test of whether or not this program is worth while. But don't look for profits immediately or tomorrow. If you believe in the concept we are espousing, you must accept the fact that you are going to have to make a personal input yourself, your company, your leadership, just as the University is, in order to derive benefit from this effort.

We are here today in this Auditorium because the leadership of the University--its president, President Stahr, Dr. Wells, Dean Weimer and many able men in this institution--have dedicated themselves to this task. They believe in this concept and they are willing to apply their own tremendous talents to finding new approaches in this new era of science and technology for bringing about new economic growth to the industrial of this region. This is a bold and far sighted effort on their part. I think it deserves the support and the same kind of effort on the part of the industries of this region as a whole.

Gentlemen, I have confined my remarks in the last few minutes to talking concept. What we are trying to do in a broad way. Mr. Fong, who is going to follow me, will now outline some of the details of the NASA programs and indicate how we plan to further this effort.

## NASA'S INDUSTRIAL APPLICATIONS PROGRAM

Louis B. C. Fong  
Director, Industrial Applications  
National Aeronautics and Space Administration

Dr. Wells, Dean Weimer, distinguished citizens of Indiana and adjacent regions: I certainly echo Colonel Young's words that it is a real opportunity to come before you and tell you about one of NASA's most intriguing and challenging programs. We particularly appreciate the opportunity of being here today when you are about to kick off here within the state a rather unique relationship between the University and industry to help us in this very difficult problem of transferring information from government R & D to the civilian industrial community.

NASA's Industrial Applications Program represents the first major organized effort to turn the results of government R & D in many fields of endeavor back to the civilian economy. While we do have the pattern of the Atomic Energy Commission to fall back on, I think you realize, as Colonel Young pointed out, that they were confined by security, and to a certain extent, by the subject matter to which they could address themselves. They worried about the applications of radioisotopes, the applications of radiation to medicine, of nuclear energy sources, etc. However NASA, with its peacetime unclassified program extending over many fields of endeavor, is not faced with these restrictions, and therefore, its ability to transfer the output from the space program to industry should at least have a much greater potential for success.

To help us in this challenging program, Mr. Webb has enlisted an extremely able group of industrialists to serve as consultants and members of the Industrial Applications Advisory Committee. I think it would be worthwhile to just mention a few of these members who have joined us in trying to decipher some of the problems that are encountered. It is chaired by Dr. Earl Stevenson, ex-Chairman of the Board, Arthur D. Little, Inc., Cambridge, Massachusetts; and has as its members Dr. James Hillier, Vice President, RCA Laboratories, Princeton, New Jersey; Mr. Malcolm Hubbard, one of the founders of M.I.T. Radiation Laboratories and currently President of Hubbard Associates, Boston, Massachusetts; Dr. Howard Turner, Vice President of R & D, Jones & Laughlin Steel Company, Pittsburgh, Pennsylvania; Mr. Games Slayter, Vice President of Research, Owens-Corning Fiberglas Corp., right here at Granville, Ohio, and Dr. Emanuel Piore, Vice President of Research Engineering, IBM, New York.

In addition, we have three other consultants: Mr. Frank Godsey, ex-Vice President of Westinghouse Electric Corp., Baltimore, Maryland, and former President of Electronics Communications, Inc., St. Petersburg, Florida, has had experience in both big and small business; Mr. Edmund Buryan, who comes from Minneapolis, Minnesota, and was formerly president of MOTECH Industries. And, finally, we've added to the Office of Applications, the services of Dr. Joseph Barker, former president of Research Corporation, New York. As you know, the Research Corporation has the function of trying to get patented ideas worked and we expect to learn a lot from his experience.

In November, 1961, NASA instituted a pilot study effort with the Midwest Research Institute, under the direction of Dr. Charles Kimball. The Midwest Research Institute has been operating in the six-state region, encompassing Kansas, Arkansas, Iowa, Nebraska, Oklahoma and Missouri. Their pilot effort, mainly an experimental one, was to test out methods of identification and retrieval of innovations from NASA's field centers; then to translate them into potential industrial applications for dissemination to industry; and, finally, to analyze industry's response. Up to this time, MRI has used a rather broad generalized approach rather than a directed one, and have been presenting to industries in this six-state Midwestern area innovations which cover a fairly wide spectrum. These range from machine tools made of alumina, which eliminates finishing and does not wear out as fast as carbide tipped tools, to new management techniques. MRI's Mr. Howard Gadberry will go into the details and give you the results of their first year's effort. I think he has rather interesting examples of some transfers and some potential transfers.

We should certainly like to emphasize that NASA does not claim to have invented all the innovations and ideas that we uncover. I have used the word "innovations" rather freely because I'd like, for the purposes of this discussion, to have it cover both inventions as well as ideas which are non-patentable. So it is a rather broad term, you might say. I do get some static from the patent side of the picture with our use of the term, but I think for the purposes of our discussion you will understand what I am talking about. Certainly some of the ideas that NASA identifies and feeds back to the industrial community are not new; it's NASA's use of them that is unique. It is the space application that tends to stimulate new thinking on how we can better utilize existing practices, techniques or materials. We would tend to contribute increments rather than orders of magnitude in the progress of the state-of-the-art. This stimulation certainly results in improved methods, decreased costs, increased load capabilities, and extended testing capabilities.

In general, we are thinking in terms of several media of dissemination, including publications, trade journals, direct contact with industry, trade associations, professional societies, area development groups and others. Certainly we look to this Center here as a very fast means of communication with the local industrial community.

In addition to the Midwest Research Institute, we have had an effort on the part of the Denver Research Institute in studying previous aerospace transfers. The idea back of this particular study is to survey what has been done in aerospace industry prior to our entering this program. Denver Research Institute has surveyed some 3500 aerospace research industries and organizations, and we anticipate a report from them within the next month or two. The response was not too high, but I think we have some useful data from which we can learn many lessons and certainly the Center will have access to this report.

More recently, we have also invited the participation of several other research institutes in order to get a better feel for the character of industry throughout the United States. The research institutes which have been asked to participate in this program include: Armour Research Foundation, Arthur D. Little, Inc., Battelle Memorial Institute, Southern Research Institute, Southwest Research Institute and Stanford Research Institute. Now this new effort is primarily involved with evaluation of the industrial potential of NASA's innovations.

I think you recognize that there is a very logical reason for engaging people who have a better feel for industrial needs. I believe the Center here is certainly one answer to this problem because when you talk to government scientists they may not be up to date on industrial needs. It is recognized that when they write reports they are more concerned about the opinions of their peers, and make no special attempt to report on or identify potential applications. Something that is completely useful to industry might be considered as a means of getting to the ends of their job, and would not be reported. So part of our job in NASA is trying to motivate these engineers to report those items in which industry has an interest.

NASA has concentrated on its own in-house efforts and a program was formally initiated in July 1962 designating an Industrial Applications Officer at each Center. In some Centers, where it is demanded, we have a much larger staff. For example, at the Marshall Space Flight Center with a total complement of over 6,000 people, there is an Industrial Applications staff of seven people. To tell us if somebody has an idea with a potential, we have evolved and developed a reporting system for sending the idea to Headquarters. Since the inception of this retrieval system, we have at the present moment 440 ideas which are in the process of being evaluated.

I might give you some inkling of how these ideas fit with respect to the broad fields of categorization which we have initially chosen. We look forward to your Center to help us in evolving and developing industrial categories which would be more useful to you. Initially we have broadly categorized them into the following:

1. The electronics and electrical field cover almost one-third of the ideas.
2. Another one-third are in the mechanical field, which includes metal fabrication, metal forming, metallurgy, with some falling into the civil engineering field.
3. The remaining third covers life sciences, which encompasses medicine, foods, drugs and agricultural products; materials; and energy and propulsion sources.

Materials, by the way, not only encompass synthetic materials, but also include some of the newer alloys made up of tungsten, columbium, etc. I might state that the chemist who started out in the materials field has gotten so intrigued with the life sciences field that he has decided to study biology and go over into this area.

The reason for the small input for life sciences, even though it has a very distinct importance in the space program, is the fact that very little of our output is from our out-of-house or the contractor effort. We look forward rather eagerly to the input from NASA's contractors. Now the totals which I have been talking about are mainly from NASA's in-house efforts. I think it is interesting to note because only ten cents of every space dollar is spent in in-house efforts. This supports the 25,000 in-house NASA staff. We have yet to tap our contractors' efforts which absorb 90 cents of every space dollar.

We have recently engaged an industrial contractor to study the problem of how to motivate NASA's industrial contractors to feed back this information to the space agency. I think being in industry

you can see some of the problems. We certainly have to think of ways of differentiating between proprietary rights, company know-how and competitive know-how. I don't think the program intends to try to retrieve this type of information. But I think it certainly is looking for that kind of information which would help industry in general and not take away some of the aspects of our free enterprise and competitive system.

We certainly anticipate that the Industrial Applications Program will help to alert industry and capital to the many opportunities arising from space research. And we sincerely hope that through this program we can fully support President Kennedy's statement on the space program so that "it can contribute to the acceleration of the nation's economy thus creating new products, processes, materials and opportunities for employment of skills and investment of funds."

Now I think we look forward to your Space Center here with considerable eagerness and enthusiasm. I think we are looking forward to the same degree of competence and capability that this little story about Colonel Glenn will illustrate. It has its humorous side, but I think it truly is a tribute to American industry's capabilities to arise to the needs when they come about, and to meet the problems squarely. Colonel Glenn, when he was about to take off on his memorable Mercury flight, was approached by a reporter who happened to get past all the barriers and peered into the capsule.

"How does it feel Colonel Glenn?" he asked.

"Well," Colonel Glenn replied, "how would you feel if you were strapped down just as tight as can be, could only move your eyeballs and were staring at 150,000 components which were awarded to the lowest bidder?"

Aside from the humor, the true significance of the story is that American enterprise has risen to the need and the challenge of the space program.

We certainly see in the objectives of this Center, where you intend to have a very close and viable relationship between the University and the industrial community, an activity which will expedite the transfer from government R & D to industry. I think that the Center's awareness of industrial needs and problems should facilitate the very close matching against the R & D output which you'll get from government.

As I've already told Dean Weimer, NASA is not working on this task in isolation. We are cooperating very closely with the Department of Defense, the Department of Commerce and the Atomic Energy Commission. In fact, I meet with some gentlemen from these agencies who are my counterparts, at least once every other month on an informal basis, to talk about plans, problems and results. Whenever we can combine our efforts, we shall do so.

We certainly anticipate eagerly the development of many new approaches from your efforts here, which we hopefully can turn around and give to the rest of the nation. We look to you people as leaders in this area for new approaches on how we can most effectively transfer from NASA's programs into the national industrial community.

## INDUSTRIAL APPLICATIONS OF AEROSPACE RESEARCH

Howard M. Gadberry  
Assistant Director, Chemistry Division  
Midwest Research Institute

I want to tell you today about the program that we have been carrying on for NASA. It is different in many respects from the venture proposed here at the University. We have many features in common, too. Midwest has been carrying on this experimental effort in the six states surrounding Kansas City for just over a year. We have two more to go, so my remarks here today are in the form of a progress report, something about the methods of the project, the results to date and some of the problems that are involved.

Our program is primarily geared to actually effecting some transfers to industry in order that we may learn what mechanisms are involved, and how to go about the job better. In this regard we hope that the findings of this effort will assist NASA in mounting other efforts. Many different schemes are planned for retrieving, packaging and disseminating information obtained from the space program. The operating plan of the project is really simple if you say it quickly. You simply identify useful ideas, evaluate them and pass them on to the people who can use them. In practice there obviously are many problems involved. To avoid any possible misunderstanding, let me define what we mean by space related by-product. This is any process, material or device that has a nonspace use which has either resulted from or received impetus from the satellite, rocket and aerospace industry. Thus it can be either a new innovation or discovery, or in many cases it is an old discovery that has been made practical, and has attained widespread use because of the requirements of the aerospace program.

What are the sources of these ideas? Colonel Fong has told you about the NASA centers and their applications program. Here is the location of the NASA centers, the major ones being Lewis in Cleveland, Manned Space Craft in Houston, Marshall at Huntsville, Langley in Virginia, Jet Propulsion Laboratory and Ames on the West Coast. One of the sources of information is the innovations reported by the industrial application officer at each of these centers. Another major source is the technical reports submitted by these workers--25,000 scientists and engineers working across the spectrum in all the industrial technologies and sciences--and the contractors for NASA. This amounted to about 4,000 reports last year. A third source of information is the NASA patent disclosures, and a fourth source of information is the technical papers and announcements arising from the aerospace industries. Many of their developments are first reported in technical meetings.

After about seven months of talking to businessmen throughout six states--2,400 businessmen representing perhaps 650 or 700 firms--we have learned the kinds of information coming out of the space program that are of greatest interest to their firms. But one of the basic problems involved here is that relatively few businessmen can identify themselves as potential beneficiaries of the space program. They say, we make air conditioning and heating equipment. What have we got to do with the space program? So one of the things that we have to make abundantly clear to these people is that,

in our opinion at least, space technology will affect their business, either directly or indirectly. The corollary to this statement is that this transfer is not going to be automatic by any means. A great deal of ingenuity will be required on the part of industry to recognize the industrial applications of developments made primarily to advance the space program; to see the new technical means now at hand for the solution of their problems. Four types of information are most useful to industry: (1) new materials out of which to build things, (2) new and improved processes, better fabrication techniques, better ways of performing work objectives, (3) a host of new product opportunities. (4) Not the least of the benefits to be derived from the operation of a \$3.5 billion a year operation are many management aids and techniques. NASA requires the very highest degree of quality assurance, reliability, critical path scheduling, the best philosophy of design of long life and high reliability mechanical equipment. Many of the problems that you face every day are faced on a very critical basis by NASA; their techniques certainly can be of benefit to industry.

Now I'd like to tell you a little bit about some of the specific cases, some of the information that we uncovered or that has been made available to us through the industrial application program that has stimulated considerable interest and activity on the part of the firms that we have been dealing with.

#### Frangible Tube Energy Absorber

To absorb the impact of space capsules hitting the ground at a velocity of about forty miles per hour, NASA investigated a very large number of energy absorption schemes. What you see here on the screen is actually a shock absorber. This turned out to be the most efficient energy absorber of all the schemes tested on a weight basis. It is simply an aluminum alloy tube which on impact is deformed over this die beyond its elastic limit and absorbs a great deal of energy and is fragmented off in this "popcorn." Here you see a high speed sequence photo showing a model of the Apollo capsule hitting a concrete slab at 40 mph; and in six inches of travel being slowed to a stop with an even acceleration which never exceeded 7 G's. That's about like falling out of bed. Potentially this device can be used for many types of overload energy absorption, specifically a helicopter manufacturer with whom we have been talking is quite excited about the possibility of using this energy absorption tube as an overload shock absorber on their landing gear. In the event of an autorotation landing at low altitude, the helicopter can be seriously damaged when the springs and shock absorbers bottom out. With this type of device, lightweight, highly reliable, requiring no maintenance, the deceleration can be pre-programmed so that the energy can be absorbed; and an additional feature is that it clearly shows if the design loadings of the landing gear have been exceeded. This is an example of a fairly direct transfer. A concept developed specifically for a space mission job, and now the helicopter manufacturer has his engineers designing overload shocks based on the frangible tube principle.

There's another type of transfer which has been perhaps typical of many of the things we have encountered, an indirect transfer, in which you can't find a very continuous thread. Let's examine a typical case here, that of gas bearings.



## Gas Bearings

Certainly engineers talked about gas bearings, that is the lubrication of surfaces with a thin film of flowing gas, before the war. But actually it was the precision techniques required for inertial guidance, stable platforms in launch vehicles, satellites, that made possible much of the technology that today has made gas bearings one of the hottest topics in new product design. There are a great number of types of gas bearings, both externally pressurized and self acting, ranging from the very large journal bearing, such as those on the main shaft of our nuclear submarines down to tiny journal bearings in dental drill sets which revolve at 400,000 rpm. The swivel thrust bearings which we have seen used throughout all of the space simulators provide substantially free three axis motion around the ball suspension.

This is a conical thrust air bearing isolator. We were discussing air bearings with the Western Electric Company who make transistors. They use a large number of precision microbalancers to weigh the "dopants" in their transistors, and they had discovered to their dismay that precision microbalances just aren't compatible with punch presses on the same factory floor. They asked us if an air bearing isolator would float these balances free from building vibration. We thought so. We loaned them our air bearing demonstration rig. They tried it on one of their balances, and it worked so well that they have prepared their own specifications and have requested AstroSpace Laboratories, Inc. of Huntsville, Alabama, to produce some air bearing isolators of this general design for their microbalances.

But the simple flat pad bearing is perhaps the most versatile, and the one we have encountered the most in our tours through various NASA centers. Here at Huntsville you see an engineer standing on an air bearing platform supported on three flat pads to simulate one of the weightlessness conditions that will be encountered in doing repair work in space. What the engineer has learned here, is that you can't use an ordinary wrench to tighten a nut in space. Just one good twist of the wrench and the nut stays still while the operator goes sailing away. Until you have experienced the sensation of having no coupling to the earth, floating essentially free in the air, (although you may be only .003 of an inch off the surface) you can hardly imagine the sensation.

The industrial application of the air pad bearing is largely for moving very heavy loads. The young lady is easily maneuvering 10,000 pounds across the air bearing plate with the tip of one finger. Air bearings are virtually frictionless. The primary concern is with overcoming the inertia of the load and the air resistance, just as though the load were suspended on an infinitely long pendulum from above. General Dynamics has utilized this principle in making a precision sheet metal welder. They use cylindrical ways and gas bearings to improve the vertical tolerance of their welder ten fold. The best ball bearing assemblies that they could obtain previously permitted a vertical movement of .005 of an inch, as the welding head was extended five feet. By going to gas bearings they cut this to one-half a thousandth and were able to improve the precision of their welder tenfold.

If you take a mechanical idea like this and transfer it over into the field of medicine, the results can be quite startling. Some of you may have had cardiograms taken to test your heart. The most common type, the electrocardiogram, is not capable of detecting incipient or very early heart disorders. There is a newer type of cardiograph called the ballistocardiograph which works on the principle of recording the recoil of the heart. The firm that I mentioned before, AstroSpace Laboratories in Huntsville,

a group of men who actually learned their trade while working on the guidance system for the Saturn, have prepared and offered commercially this air bearing ballistocardiograph in which the patient lies on a table which is just as steady as a rock until the air is turned on. Then he is floated free, completely isolated from building vibration. The older type of ballistocardiograph used long wires from the ceiling, and after you had climbed on this shaky platform, building vibrations coming down the wires frequently interfered with diagnosis. With this new design we have an ideal example of an indirect transfer from inertial guidance to better heart diagnosis. Certainly this is a primary example of the indirect and devious route that a space related development can go through before it finds commercial application.

### Magnetic Pulse Metalworking

In the space program a great variety of high energy rate metal forming processes are being developed. Here on the Saturn tankage program at Huntsville, they have greatly extended the concept of magnetic pulse metal forming, in which electrical energy is stored in banks of capacitors and dumped into this coil in a matter of a millionth of a second. The eddy current set up forces the metal to expand or contract either against a die or against a mating work piece. In this hydrogen peroxide tank for Saturn, by placing these corrugations along the tank, they were able to reduce the wall thickness of this aluminum tank from 3/10 of an inch to 1/10 of an inch. NASA's contribution here has been largely that of extending the range of this technique to very large sizes of work and fairly heavy wall sections; and they have reduced the machines involved to a small hand-held portable unit that is ideal for doing magnetic swedging. If any of you make devices that have swedged fittings, cable end connections, electrical assemblies, I suggest you look into the possibilities of magnetic swedging. Magnetic swedging shrinks the metal around the work piece with far less spring back than any other technique which we know making a stronger, safer joint.

A firm in Kansas has a problem, a fairly prosaic problem perhaps, but nonetheless important to them. They make camping equipment, and they were having trouble keeping the ends of Nylon rope from fraying. We suggested to them the magnetic swedging of aluminum or brass ferrules or fittings on the end of their nylon rope and it seems to be working quite well. If you have every tried to tie a knot in the end of a nylon rope, you will appreciate this homely example. Incidentally when that fitting is on the end of that rope, it's on there so tight you can't pull it off with a testing machine.

### Reliable Soldering

I mentioned some of NASA's management concerns with things such as quality assurance and reliability. In order to obtain the high reliability that they need in their electrical assemblies, NASA has found it necessary to redo the conventional MIL-spec soldering technique for highest electrical reliability. To implement this, they have developed two special soldering schools, one at Western Operations Office in Santa Monica and the other at Huntsville, where a two week course is put on to train soldering supervisors and inspectors to solder to high precision and high reliability requirements. Just as an example of this, one of my associates decided he would see if there was really anything to these new methods, so he made a chain of twelve series connections following the MIL-spec procedures and another using the NASA procedures. With any ohmmeter of good sensitivity, you can measure the improvement.

The Halliburton Oil Company of Oklahoma, a firm which is primarily concerned with field measurements such as oil well logging and geophysical prospecting, found that one of their major problems was the failure of their electronic and electrical equipment in the field. They obtained from us several copies of the NASA soldering manual and put on their own training course. They wrote recently that since adopting the new procedures, failures of equipment in the field have fallen forty per cent.

### Sintered Oxide Ceramics

This is an alumina ball which we found in use in a liquid oxygen system. It was selected for this use primarily because it could be ground to be perfectly spherical on ordinary ball bearing grinding equipment at room temperature, and it would stay spherical when cooled to liquid oxygen temperatures. Unlike steel balls the grain structure of the materials doesn't take it out of round, and the ball retains its sphericity from about 1,000 degrees down to liquid hydrogen temperatures. This is the reason it was put in use; then they found they had a bonus. In actual use this ball which is as hard as a sapphire will outlast hardened steel check valve balls by a five to one factor.

A St. Louis refrigeration firm had a similar problem in the small poppet valve in their refrigeration unit. They were somewhat apprehensive about the cost of aerospace material. This is one factor that industry is understandably anxious about. They figure that if the space program can afford it, they certainly can't. This isn't necessarily true, and the St. Louis manufacturer was delighted to find that balls he wanted in the size for his expansion valve cost \$.22 a piece.

### Refractory Weld Back-up Tape

Many of the ordinary industrial technologies are involved in NASA's work. After all, what is space technology? It is essentially the engineering techniques used by the very most advanced aerospace contractors to solve their engineering, fabrication and design problems. This takes NASA into problems as simple and everyday as welding. Here we see once again for the Saturn tankage program, use of refractory fiberglass weld back-up tape. In making these tanks thirty-three feet in diameter, NASA wanted to make single pass welds continuously around the circumference of these very large tanks without interruption. They found they could not do this with conventional water cooled back-up bars. They tried a lot of techniques. The simple expedient of using refractory tape on the back of this weld permitted a through penetration weld with a fairly good, smooth surface. This has been of use to a large number of industries. Some of them have been able to use it; some have not. It depends upon the application. In certain applications, it may eliminate welding from both sides, essentially a fifty per cent reduction in welding costs.

### Beryllium Oxide Heat Sinks

Many of our space borne electronics use a unique material sintered beryllia. This is a ceramic material which has some very unusual properties. It combines the electrical resistivity of high grade porcelain and the thermal conductivity of yellow brass. Used in electrical assemblies like

this, the heat generating complements are in direct electrical contact with the beryllia heat sink block, which conducts away the heat, eliminating the use of fans or blowers, resulting in a lighter more reliable airborne or spaceborne part. In talking to a firm in Des Moines, we found that they were machining out by very tedious techniques aluminum resistor housings, essentially a heat sink. We suggested to them the use of molded beryllia for this purpose. Although it is initially more expensive than aluminum, they tried it. They wrote us and told us that the application of this beryllia material had resulted in substantial savings in the number of man hours required to assemble their units.

### Explosive Forming

There are many advances in technological fields such as explosive forming. Certainly explosive forming is not new; the most advanced aerospace companies use explosive forming as a routine method of fabrication. But we found in checking around our part of the country that very few firms had working know-how and capabilities in explosive forming. By explosive forming, very large complex shaped assemblies such as this can be fabricated. A firm in our area wanted to make twenty foot diameter dish tank heads, one inch thick. They had convinced their management to invest \$4 million in a hot spinning facility for this purpose. Then we told them about the possibility of doing this by explosive forming techniques. We made available to them NASA reports on explosive forming of dished tank heads as large as 160 inches in diameter, put them in direct contact with the two men at Huntsville who supervised this work. They made an engineering study of the costs involved. We checked with them last week to see how the program was coming along. They have substantially abandoned their plans to build a \$4 million hot spinning facility. They now plan to go ahead and manufacture these twenty foot diameter tank heads by explosive forming at a cost saving of \$2 million.

### Fire Restive Foam Insulation

If you have an astronaut to protect, the best is none too good. Here we see Scott Carpenter practicing entry into the escape vehicle used at Cape Canaveral to protect the workmen in the event of a disastrous fire. This aluminum bodied track vehicle is insulated on the outside (the furry looking coating) with three-fourths of an inch of thermal insulation. The foam insulation is sprayed on and its design specifications call for protecting the occupant for 30 minutes from a 2,000 degree fire raging on the outside. The temperature inside that aluminum van never rises above 100 degrees. This is truly a very fine insulation. It's a little bit expensive. There are a number of similar materials which we think have considerable possibility in fireproof building panel construction; to make possible the construction of light weight thin wall fire resisting office equipment, safes, files and so forth. Most exciting of all is the possibility that this might replace the concrete now put around structural steel, not for strength purposes but to protect the structure from a fire.

### Cold Galvanizing

Do any of you have corrosion problems? Well, so does NASA. This is Launch Complex No. 34 down at the Cape. It is now the tallest structure in the state of Florida. You can get some idea of the size of this structure

if I can find the men standing here. This structural steel assembly is exposed to coastal humidity, fog, blowing sand, workmen climbing over it and frequent changes by welding. How would you protect that from corrosion? NASA investigated many different schemes for protecting these assemblies and finally selected a "cold galvanizing" technique in which one coat of galvanic paint is applied at the factory, the steel is shipped to the Cape, erected, a second coat is applied and sealed. This has turned out to be the least costly means of protecting this structure, and it is now being very widely specified for a number of industrial steel structures, some of them already in place and needing protection, while others find it desirable to protect such things as rocker panels of automobiles.

### Non Lubricated Bearings

We never really needed to operate ball bearing assemblies in the hard, cold vacuum of space until a few years ago. Lubrication in space is quite a problem. Now engineers working on this problem have essentially solved it. When we were at Lewis Laboratories in Cleveland, we saw many bearing assemblies undergoing tests. Here is one operating at liquid hydrogen temperatures in an unlubricated condition. We are told that by the use of a ball bearing retainer comprised of fiberglass reinforced Teflon impregnated with molybdenum disulfide, the bearing can operate essentially for the fatigue life of the metallic components. You don't need to send an engineer around occasionally to lubricate your satellites.

### Printed Cables

Those of you who may be driving a 1962 Buick are already beneficiaries of some of NASA's ingenuity. This is the wiring harness behind the dashboard in a 1961 Buick. The engineer told me that he didn't have a man in his factory who could put that assembly in right the first time. This is printed cable. It is a flexible, multi-conductor assembly developed by Von Braun's group, carried to a very high degree, checked out on performance primarily to reduce the weight and improve the reliability of missile wiring. As you saw, many of the early Polaris launches were failures. You perhaps saw in photographs a gaggle of wires trailing out the back end of the assembly. The wiring was simply torn loose; it could not stand the acceleration of launch. With printed cable you can cement the cable directly to the supporting structure. It is very light weighing only about 15% as much as conventional wiring. Buick adopted this principle last year. This darker colored flexible wiring assembly is made by a small firm in Chicago under contract to them and cemented to this acetal injection molded dash insert. Notice particularly that it forms not only the wiring for the dashboard, but the light sockets for the lamps as well. It turns out that the cost of this assembly and the hand made unit is about the same. So this is not a cost saving feature for Buick, but there's not a man in the factory who can put this one in wrong. Savings of assembly time and freedom from trouble within the warranty period makes Buick happy to be participating and benefiting from the extensive development work performed at Huntsville.

### Silent Chain Friction Drive

One last item. Occasionally, budgetary problems produce some unusual innovations from NASA. When we were at the Ames Research Center in Palo

Also we saw the very large five degree of motion simulator that was developed for pilot training. This revolves a pilot cab around in a huge circle, moves it up and down and gives it pitch, roll and yaw. To drive this unit they needed a powerful, precision drive assembly. What they wanted was herringbone gears five and ten feet in diameter. I don't know if you have priced any of those gears recently. They couldn't get delivery in time so they made an innovation. It is simply the use of silent timing chain, sprocket driven, running against a flat pulley faced with 3/16 of an inch of a special neoprene. The static coefficient of friction of this drive assembly is phenomenally high, over .96 in any test that we have seen. This drive completely solved NASA's problems. It turned out to be quiet, it was more precise than the gear drive and it has less accumulated back lash. It has operated successfully for two years without any trouble. And I think this is significant, NASA has carried this development as far as they intend to carry it. They have made the innovation which solves their problems. They aren't going to do any more development work on it. Many industrial firms are now interested in this power transmission device because of its low cost; its quiet, high precision permits its use in servo loops. But there are lots of things we don't know about it yet. How much power can it transmit? How long will it last? How big can it be made? How small can it be made? What are the limits of application of this device which was developed to help NASA complete their pilot training program on time?

These are a few of the things that we have seen that stimulate the greatest interest on the part of industry. There are some problems involved here. It does require ingenuity on the part of industry. Much of our effort has been directed toward assisting industry to make matches between their problems and the possibility that somewhere in the space program a similar problem may have been encountered and the solution may already be at hand. I am sure that in the plan that Dr. Wells has you are going to see many similar exciting transfers of technology from the space program to ordinary commercial enterprise.

## PLANS FOR CENTER OPERATIONS

Arthur M. Weimer  
Co-Director, Aerospace Research Applications Center  
Dean, Graduate School of Business

It may seem somewhat incongruous to mention the name of Adam Smith in a conference on industrial applications of aerospace research. But Adam Smith once made a statement that is highly pertinent to our discussions today. He said: "It is not from the benevolence of the butcher, the brewer, or the baker that we expect our dinner but from their regard to their own interest."

In this conference we hope to appeal to "your own interest." We hope that our new Aerospace Research Applications Center will be of direct benefit to the participating companies by facilitating the channeling of new information, ideas, concepts and processes to their work in a practical manner. We believe the new Center will aid the University by stimulating the development of efforts in the sciences and in business administration. Beyond this, we believe that it may contribute to the further economic development of this region and thus enhance the well-being of our people in their everyday lives.

I have been asked on occasion why those of us in the Graduate School of Business should be concerned with programs like those related to our new Center. People understand fairly readily how our science departments or a school of engineering might be interested in such an effort, but why a graduate school of business?

The answer, it seems to me, is fairly clear. The adaptation of aerospace research to industrial uses is primarily a managerial and entrepreneurial problem. Unless the heads of our business firms--large and small--become interested in the possibilities involved and as a result stimulate their managerial, scientific, engineering and other personnel to develop effective applications of aerospace research, little will be done.

Beyond this, in the programs of our new Center, we need the imagination and entrepreneurial spirit that is characteristic of business leaders. During the discussions with Mr. James E. Webb, the administrator of the National Aeronautics and Space Administration, which led to the establishment of this program, he referred on several occasions to the importance of the entrepreneurial mind in the success of programs of this type. The entrepreneurial mind is not easy to define. Certainly it is represented by such qualities as imagination, creativity, and originality. Beyond these it probably includes certain elements of daring and risk taking that we more frequently associate with the business entrepreneur.

We need this entrepreneurial spirit in all of the efforts related to the programs of our new Center. We hope that through close association with business leaders, we may help to capture this entrepreneurial spirit for the Center and for all associated with it.

The entrepreneurial mind is undoubtedly one of the great assets of the American economy. In all probability we need to do more, in our programs of study, toward identifying and developing young people with entrepreneurial minds. For present purposes, however, we believe our first task in the development of a successful program through our new Aerospace Research Applications Center is to enlist the help of business leaders in this region and to capture some of their talents and those of their associates in order that we may all serve our own interest better.

In order to do this we plan to operate our new Center through a system of company memberships. Through these memberships we believe that we will be able to enlist the best entrepreneurial, professional and technical talent in this area and as a result to stimulate a wide variety of benefits for all who are involved. We believe there will be numerous practical benefits for the participating members--and beyond this, we believe we can contribute significantly to the further economic growth of this region.

A form indicating the nature of memberships in the Center is available in the folder that has been provided for you. Basically a membership arrangement involves support for the Center both financially and in terms of expert manpower. The memberships have been set up on the basis of \$5,000 per year, with the proviso that in some cases expert personnel may be assigned to the Center in lieu of cash. Some minimal cash support will be required of each member; some companies, notably the larger ones, may provide both the \$5,000 cash support plus the services of selected personnel. We will try to plan the most effective working arrangement for each member. We may wish to modify the membership arrangement as our experience unfolds. For the present, we hope the types of arrangements I have outlined will prove to be workable.

Our efforts during the first year of experimentation will be limited to working with the member companies. We do not wish to exclude any interested company and hence are issuing this public invitation for membership applications at this meeting. But within the next four to six weeks we must have our membership arrangements settled and our programs started into effective operation.

At the end of the first year of pilot operations, we will review our experience and may at that time make provision for additional company members. We cannot tell at this stage just what our experience will indicate.

What will be the principal benefits and advantages for company members of the Center? These fall into roughly three groups:

1. The reorientation and development of managerial thinking relative to the space effort and its potential for industrial and consumer uses. This may form the basis for the formulation of new company plans and policies.
2. The opportunity to study the managerial methods and processes that have been worked out by NASA and its various installations to manage huge, complex and demanding operations. Many business firms can learn much from this experience relative to the improvement of organizational climate, the effective use of technical and scientific personnel, the administration of research, the processes of capitalizing on research, the utilization of extremely demanding control processes and many other things. Professor Edgar G. Williams of our faculty is already working on a study to identify some of the



most promising factors in NASA's experience that may improve the organizational arrangements and administrative behavior of business firms.

3. The opportunity of ready access to a variety of information, ideas, and concepts relative to potential products, processes and product development. It is in the field that most people have an immediate concern. The other two areas outlined, however, may offer equally great, or possibly greater promise. We have already had a number of illustrations of the possibilities in the product identification, development and improvement areas as a result of the discussions of Colonel Young, Mr. Fong and Mr. Gadberry. Of equal importance will be the identification of needs and problems of member companies and opportunities to match these against information and suggestions the Center will develop. The Computer Center will be a big help in this connection.

Perhaps I should spell out somewhat more precisely some of the potential benefits for company members as I see them at this time. These will include:

1. Priority of access to new information, and ideas and concepts through the Center; NASA cannot give us priority over other outlets, but we can develop our information to make it highly useful, and thus give member companies a definite edge in applying these concepts.
2. Participation in various panels of experts established by the Center;
3. Access to our technical library, computer services and other facilities as required for Center related programs;
4. Ready access to the Center's facilities; in some cases access to other University personnel.

We hope also to provide opportunity to participate in one or more general management meetings with NASA headquarters personnel.

We cannot point out very precisely today just how this Center will operate. One of its main functions is to experiment, to find better ways of identifying vital information and ideas and transmitting them more effectively to industrial and commercial users. Thus, the Center may be operating quite differently six months from now than the way we expect to operate next month.

Basically we plan to operate with a rather flexible organization under the general chairmanship of Dr. Wells. He will have an industry advisory committee and a faculty advisory committee to help develop guide lines for the Center. Dr. Cleland and I will serve as co-directors, thus linking together the scientific and business administration areas of the University. Three associate directors will serve as the principal operating heads of the Center: Mr. Klinge will be associate director for science; Professor Timms, associate director for engineering; and Dr. Haeberle, associate director for development, including management, marketing and related areas. In addition there will be various assistant directors for special areas; for example, Dr. Doris Merritt will serve in the Science Division as assistant director for the medical sciences and related fields.

By means of a series of working panels set up by the associate and assistant directors, information can be evaluated and channeled to the company members. In turn, the company members will serve on the panels, indicate the kinds of needs they have, and we will try to find solutions for them.

As I have suggested, the panels will be composed of both University and company personnel. Some experimentation will be required to find the best combinations of abilities for the panels. Some panels may meet once a month, others once a week. At some periods various panels may meet for extended periods. We can now envision panels for the medical sciences and various suppliers of medical science needs; biological sciences and industries related to them; chemistry and chemical industries; and similar arrangements in other fields. We also believe it desirable to establish some top management panels, both in general and for specific industries, marketing panels in various fields, and of course, we plan for engineering and product development panels of various types. We hope that member business firms will supply personnel for various of these panels as required; we hope also that they will make suggestions in regard to the types of panels and panel arrangements they believe are likely to be most successful.

In addition to the work of the panels, we plan to operate a technical library that will be continuously available to all members. This library will work to some extent in cooperation with our Computer Center, since some of the NASA information will be channeled to us by means of computer tapes. We hope to have a highly usable system of classification for the materials in our library. We have been assured by NASA that we will have access through the Center to a wide variety of information that has been identified, recorded and classified, not in the military sense of classification, but classified for ready industrial and University use.

Some of the results of our efforts can be used in connection with various of our existing programs. Without violating agreements with member companies there will be some experience resulting from the work of the Center that will help the University's scientific efforts, our Executive Development Program, Management Institutes and related programs in executive education, and some information of fairly widespread public interest can be presented in Business Horizons, the Indiana Business Review and other publications of the Bureau of Business Research. Many of our teaching programs will be enriched as a result of the work of the new Center.

In all cases, however, member companies will be given every priority, their interests will be guarded as carefully as possible, both as individual companies and as a group of companies associated together in the efforts of the new Center. We hope to deal fairly with all member companies, to treat all of them as nearly alike as possible, and to work toward the best interests of all of us.

We recognize that we will face many problems. For example, there are a number of problems in regard to proprietary interests in information and ideas. We, of course, cannot take responsibility for patent problems and other problems related to them. We know that some firms will want to withhold information from others and in a number of cases this will be quite proper. Through the work of the Center we hope to stimulate some interchange of information between companies that will be in their best interests.

I am inclined to think that member firms will have a good chance to cash in on their investments of money and manpower in the work of the new

Center. I told one of my friends that member firms realistically could be offered only a chance to gamble with us. This is true, but I believe the odds are improving every day.

In all of our working relationships, we will have to rely a great deal, especially in the early stages, on trust and confidence in each other. A great many things will have to be taken on faith--at least for a time. I am sure, however, that we have had enough experience with business executives in this region to have confidence in them, and in turn I believe they have the necessary confidence in us. As a result we have high hopes for our new Aerospace Research Applications Center.

## PANEL DISCUSSION

A panel discussion concluded the afternoon session of the Conference. The discussion was moderated by Professor William L. Haeberle, Associate Director, Development, Aerospace Research Applications Center. The following panel members participated: Robert G. Baer, Executive Vice President, Perfect Circle Corporation; Paul L. Klinge, Associate Director, Science, Aerospace Research Applications Center; E. W. Martin, Jr., Director, Indiana University Computing Center; N. F. Schaefer, Sr., Vice President, Inland Container Corporation; Richard B. Stoner, Executive Vice President, Cummins Engine Company; Sarkes Tarzian, President, Sarkes Tarzian, Inc.; and Howard L. Timms, Associate Director, Engineering, Aerospace Research Applications Center.

## AEROSPACE RESEARCH AND ECONOMIC DEVELOPMENT

Robert C. Turner

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I accepted this assignment to speak to as knowledgeable a group as this with a great deal of misgiving. My misgivings have increased as the day has progressed. I am neither a scientist, nor an engineer, nor a space technologist. I have read quite a bit--both before and since being assigned this task--about space technology. But I'll confess that I find it more than a little confusing. Samos, Explorer, Discoverer, Transit, Lofti, Freedom, Greb, Injun, Tiros, Nimbus, Aeros, Midas, Liberty Bell, Ranger, Mercury, Traac, Oscar, Apollo, Echo, Rebound, Relay, Telstar, Syncom, Redstone, Scout, Atlas, Titan, Delta, Thor-Agena, Centaur, Saturn, Advanced Saturn, Nova, Nerva. To people in the space business, these names are as familiar as Chevrolet and Ford, but they sound a bit unworldly to me.

The space language that is more familiar to me--that I think both you and I can understand--is old-fashioned dollar figures. In fiscal, 1963, about \$19 billion will be spent in the U.S. for research and development of all kinds by government, industry, and universities and non-profit institutions. About 40 per cent of this, some \$7½ billion, will be spent for military research and development, including nuclear weapons and military space activities, by the Department of Defense and the Atomic Energy Commission. Close to \$2.4 billion or about one out of every eight dollars spent in the U.S. for research and development will be spent by NASA. This \$2.4 billion is, we are told, just the beginning. The NASA research and development program will mount in the years ahead. Some of the recent estimates for the decade emanating from unofficial sources in Washington are in the \$30 to \$50 billion range. My own guess is that the total may be closer to \$100 billion. By the end of the decade, it is possible, perhaps probable, that expenditures for non-military space research and development may exceed military R and D. Even if non-military space R & D, does not exceed military R & D in dollar amount, it is almost sure to exceed it in economic significance, because virtually all non-military space research is unclassified.

These dollar figures, however, impressive as they are, do not give us the real clue that we need to estimate the economic effect of space research, because they say nothing about the character of this research. We have talked today about some of the areas of knowledge which space research is exploring. But we have done little more than get a few tastes of this multi-billion dollar research program. The examples we have discussed are probably ones where it is relatively easy to see the connection between the research activity and ordinary human activities. Most of space research--most of any scientific research these days--has moved into a brave new world--a world that most of us ordinary mortals find strange, incomprehensible, non-human.

Last week's issue of Time magazine carried a review of a recent book, The 7th Annual of the Year's Best Science Fiction. The reviewer notes that only a few of the stories in the book are, in fact, science fiction. One

reason for the dearth of good science fiction stories, the author of the book suggests, is that science has caught up with science fiction. Or more likely, Time believes, is the possibility that,

"...science fiction is suffering from exhaustion of the accessible pay dirt. Its classics, such as Conan Doyle's Lost World, and H. G. Wells' Time Machine, were skillful storytelling based on knowledge of the science of their time. In those days, almost any educated fellow could follow the advances of science. Today few writers can follow the scientists into their increasingly complicated jungles, and what they find does not support good storytelling. Science fiction will have to take a breather until neutrinos, wave mechanics and information theory grow familiar enough to be clothed in human terms."

Even as little as one generation ago, it was relatively easy to trace the linkage between scientific research and development, and industrial activity. This part of the country--Indiana, Ohio, Michigan, Illinois--are industrially what they are today because of scientific developments 25 or 50 years ago in electricity, automotive mechanics, aerodynamics, radio, chemistry, biological science, medicine, and similar familiar areas of study. I dare say that every business executive here tonight can identify one or more scientific developments of not-so-long ago that provided the foundation for much of today's business.

But the change in the character of scientific research and development that has made it difficult to write science fiction also makes it difficult to see the linkage between science and day-to-day industrial operations. This change has several dimensions. First, the relative importance of basic research, as opposed to applied research, has increased greatly, especially in the case of publicly financed research. Instead of focusing primarily on end products--motors, vehicles, home appliances, and the like--research has shifted back toward the atomic and sub-atomic nature of matter and the anatomy of energy. Some thirty years ago, when I was an undergraduate student of physics and chemistry, I was told that solid-state physics was all but a closed book. In the past ten years, more scientific papers on solid-state physics have been published in the scientific journals than in all of previous recorded history. As long as research was concerned primarily with end products, industrial applications were fairly obvious and the number of potential contributions was fairly limited. Conceivably, all the inventions of this kind could be invented. But once we start exploring into the nature of matter and of energy, the increase in the number of permutations and combinations, by the time the end-product stage is reached, becomes exponential.

A second characteristic of contemporary research and development is its extreme complexity. This complexity arises partly from the obvious fact that it is more advanced; today's research has always been more complex than yesterday's.

Partly, it arises from the fact that the instruments--the tools--of research are far superior to those of a generation ago. Symbolic of this superiority is the computer, successor to the calculator. One might devise a Parkinson's law of research: the complexity of research automatically expands to consume the capacity of the available tools for doing research.

But the most important reason for this complexity, I believe, is the fact that the progress of science has had the effect of tearing down the walls between scientific disciplines, of revealing the unity of nature. The

day once was when man could do advanced--for his time--research in botany without knowing much about chemistry, or in chemistry without knowing anything about nuclear physics. Not so today. Increasingly, science has become an integrated whole, and almost any sophisticated scientific inquiry inevitably reaches into several of the conventional scientific disciplines. This is the reason, of course, for the team-work approach to so much of contemporary research. I am told that NASA utilizes scientists of almost every description, from nuclear physicist to micro-biologist, from neurophysiologist to astronomer, from metallurgist to meteorologist, and that an effort like Project Gemini requires the co-ordinated efforts of thousands of scientists and technologists in hundreds of different fields.

Still a third attribute of contemporary scientific research and development is the point Time magazine makes--the extent to which the work of science has gone beyond the realm of experience of the ordinary man. We comprehend by associating the new and unfamiliar with the old and familiar, with something which is already a part of our experience. A microbe I can comprehend; it's something like a bug. But DNA eludes me. The atom I can visualize, but anti-matter baffles me.

I think it is this aspect of space technology that causes many of us to be hesitant about getting involved in it. The whole business seems so foreign to everyday experience. Space is a long way up there; none of us has had any experience with that empty area. I have been fairly cold at various times in my life, but absolute zero is just a number to me; I can't feel that degree of cold. Archibald MacLeish recently said,

"...the knowledge of the fact has somehow or other come loose from the feel of the fact, and...it is now possible, for the first time in human history, to know as a mind what you cannot comprehend as a man...Not until mankind is able again to see feelingly...will the crucial flaw at the heart of our civilization be healed."

My point is not so ambitious as healing the crucial flaw at the heart of our civilization, but rather the much simpler one that, modern scientific research and development being what it is, it is difficult for businessmen and students of the business process to get a real feel for the applicability--the linkage--of this research to business operations.

Yet, the linkage is surely there. In the future as in the past, economic development--economic growth--will be determined by much the same influences that have determined it in the past. These influences have been the subject of intensive study in recent years, partly because of the political attention that has been directed toward our lagging rate of economic growth, and partly because certain economic regions of the country have surged ahead much more rapidly than have other areas.

These studies have yielded much valuable information. We know a lot more about the growth process than we did even as little as 10 years ago.

Since 1929, a real GNP in the U. S. has increased by about 2.9 per cent, compounded annually. Of this 2.9 per cent, about 1.3 per cent can be attributed to increases in total employment and about 1.6 per cent to other factors. It is this remaining 1.6 per cent that is of primary interest to us, because the 1.3 per cent average annual increase in total employment has been almost matched by the increase in population,

i.e. the percentage increase in the number of hands that work has been nearly matched by the increase in mouths to feed. The increase in output per man is a fairly good measure of the increase in our real standard of living.

Output per worker would have increased substantially more if we had not elected, over this time period, to shorten the average work week by some nine hours. Output per man-hour worked in the total economy increased by about 2.1 per cent.

A recent study by Edward Denison attempts to identify the sources of this 2.1 per cent and to determine what per cent can be attributed to each source. He investigates a long list of factors, 18 of them, including the effect of shorter hours on the quality of work, increased experience and better utilization of women workers, changes in the age-sex composition of the labor force, changes in the quantity of land and of capital in use, waste of labor through underemployment, chiefly in agriculture, shifts in labor from low to high productivity industries, increased efficiency due to economics of scale, etc. But the striking thing about this study is that two influences account for well over half of the total. It may surprise you to hear that the increase in the quantity of capital--plant and equipment--is not one of them--this runs third, accounting for 28 out of the 210 points to be accounted for.

Number one is education of the labor force, which he estimates accounts for a third of our productivity increase--67 out of 210 points. This estimate, please note, does not include allowance for the expansion of knowledge that education has made possible. It is intended to measure only the increase in worker productivity resulting from education. Educated workers are better workers.

An incidental point which is not particularly relevant to my theme tonight but which might interest you is this. And these figures I derive not from the Denison study but from some work done by Gary Becker. He estimates that the annual net rate of return on an investment in a high school education is 14 per cent. This measures only the increase in productivity, over and above that required to amortize the cost of the education, and not the psychic or consumption values that the educatee may derive from his education. The rate of return on a college education is calculated at 9 per cent, which figure compares favorably with the rate of return on investment in capital. A similar calculation by Theodore Schultze of the University of Chicago shows that the cost of a college education (including income foregone while in school) is returned to the student nearly elevenfold in increased earnings over the course of his lifetime, of a high school education 11.4-fold, and of an elementary education fortyfold.

To get back to my one third of productivity increase attributable to education: It is not likely that this percentage will be as high in the future as it has been in the past. In substantial measure, it reflects the fact that 25 or 50 years ago, a considerable proportion of our population was illiterate, or so close to it that work efficiency was seriously interfered with. Tremendous gains in productivity were made simply by replacing these illiterates with workers with a grade school education. Today, less than 5 per cent of our population is classified as "functionally illiterate," and many of these are quite old people. This opportunity for easy improvements in productivity does not exist today to anywhere near



the degree that it did a generation or two ago. We will still step up productivity by raising the percentage of students who complete high school, and by increasing the number and percentage of students who go on to college and to graduate school. But the rewards to society, in the form of increased productivity, though high, are not as lush as are the rewards of transforming illiterates into literates.

The source of productivity which runs a close second to education in Denison's estimates is the advance of knowledge. This, he calculates, accounts for 58 of the 210 points, or close to 30 per cent of the total. This factor includes advances in knowledge of all kinds that, when and if applied, increase the national output that can be produced from a given input of labor, capital, and other resources. It includes both technological knowledge and managerial knowledge. How much should be attributed to each is impossible to calculate. Indeed, the distinction between the two is a blurred one. Would you classify, for example, the use of computers for inventory and warehouse control an advance in technological knowledge or in managerial knowledge?

Denison estimates that, in the 1960-80 decades, the contribution of the advance of knowledge to economic growth will be more important than any other factor, including education. Numerically, he estimates that its quantitative value will increase from 58 to 75 points, chiefly as a consequence of the enormous current expenditures for scientific research and development.

But, as I implied a moment ago, scientific research and development are not enough. They contribute to productivity and economic growth only "when and if applied." And this application of new scientific developments is risky business. Nicholas Kaldor, the eminent British economist, had this to say about the growth process.

"The most plausible answer to the question why some human societies progress so much faster than others is to be sought, in my view, not so much in fortuitous accidents...or in favorable natural environment...but in human attitudes to risk-taking and money-making...

"It is the economy in which businessmen are reckless and speculative, where expectations are highly volatile, but with a underlying bias towards optimism, where high and growing profits are projected into the future and lead to the hasty adoption of 'unsound' projects involving over-expansion, which is likely to show a higher rate of progress over long periods; while it is an economy of sound and cautious businessmen who are slow at reacting to current events, which is likely to grow at a slow rate...

"This is not to suggest, of course, that the long-term trend of growth is simply a matter of the recklessness of society's entrepreneurs. The external 'conditioning factors' are still there--in the sense that there probably always is a maximum attainable rate of saving, a maximum attainable rate of population growth or a maximum attainable flow of new ideas. But the point is that the actual values of these variables...are not determined by their theoretical maximum values, but are capable of being slowed down or accelerated in accordance with the push or pull exerted by entrepreneurial behavior..."

Dean Weimer asked me to talk on the relationship between aerospace research and economic development. I'm afraid I haven't stuck to the subject very well. I have tried to say that, in spite of the fact that much of contemporary scientific research and development seems alien to our ordinary, human experiences, it will be a dominant factor, perhaps the dominant factor, in economic development in the years ahead, that burgeoning space research already accounts for a substantial portion of all R and D, and that it will account for a rising proportion in the years immediately ahead. I would not argue that, from the point of view of economic growth, this is the most efficient way to spend this kind of money. The same might be said of military research. But the fact remains that the money is being spent. The research and development, on a massive scale, is proceeding. And the really determining factor, from the economic growth point of view, will be the daring, the boldness, the bias toward optimism of business executives in their applications of the results of this research to current operations.

In more specific terms, and at the risk of repeating many of the ideas we have talked about today, I think we can say that space programs will affect economic growth in the following ways:

First, space research and technology will increase labor productivity through its far-reaching effects on methods of producing existing products--effects which either reduce costs or improve the quality of the product.

Second, space research will generate new consumer products, and new variants of old products including particularly products made of new and superior materials.

Third, by creating new products, space research will stimulate new demand, create new markets, and in turn stimulate capital formation. All of these lead to economic growth.

Fourth, space research is obviously going to have widespread effects on the communications industries. Economic progress in this area, resulting from space activities, will be impressive.

Fifth, space research is likely to have significant, though I will admit unpredictable, effects on transportation industries--and I'm not talking about space flights for the summer vacationer.

Sixth, I suspect that space research will have an important bearing on managerial knowledge. Especially, the experience in a research program this massive may provide some valuable insights into the problem of the management of research personnel who are, I am told, a quite different breed of humans than ordinary workers. Peter Drucker has an article in the current issue of that lesser-known competitor to Business Horizons, the Harvard Business Review, the burden of which is that most business firms have a lot to learn about managing research programs and research personnel. Perhaps space will help.

Seventh, although I will confess that the linkage here is much harder to trace, I believe that the space programs may have some profound effects on government, especially state and local governments in their numerous and costly service activities. An example would be technological developments applicable to highway building and to traffic control.

You can no doubt think of others that are not included in this admittedly incomplete list.

Let me close by quoting a British minor nobleman and brilliant engineer, Sir George Cayley. He invented the airplane almost a century before the Wright brothers made their first flight--in the sense that he discovered the aerodynamic principles of the airplane wing and the propellor. All he needed was an engine and the fuel to run it.

For all his brilliance, he wasn't quite daring enough. In 1809, he said:

"I feel perfectly confident that aerial navigation will soon be brought home to man's convenience and that we shall be able to transport ourselves and our families and their goods and chattles more securely by air than by water and with velocities of from 20 to 100 m.p.h."

The moral, I think, is obvious.

APPENDIX

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AEROSPACE RESEARCH APPLICATIONS CENTER  
INDIANA UNIVERSITY FOUNDATION  
BLOOMINGTON, INDIANA

OPERATING MANUAL  
describing  
ARAC Services

1. Summary - ARAC Operations
2. Library Service
3. Industrial Applications Service
4. Engineering Service on Current Problems
5. Scientific Programs
6. Management and Related Programs

AEROSPACE RESEARCH APPLICATIONS CENTER  
INDIANA UNIVERSITY FOUNDATION  
BLOOMINGTON, INDIANA

ARAC OPERATIONS

Summary

Enclosed are five copies of a set of memoranda which will form an operating manual for ARAC services to member companies for the first quarter. Most of these were outlined at the March 21 organization meeting. We believe that these materials will be useful to you in organizing your company effort to take advantage of ARAC services.

We will operate on the basis outlined for the first quarter (April through June). With this experience behind us, we will have an evaluation meeting in late June in which, among other things, we will critique these services and decide on such revisions as may be required for the second quarter of operation. Proceeding in this fashion by quarters through the experimental year, we believe that we will have effective operating procedures established by the end of the year and documented for reports to NASA.

You will note in these materials that ARAC services are initiated in great part by our knowledge of member companies' major technical interests during the next two years (question 8 on the form Inventory of Technical Capabilities and Interests).

For companies who have not sent us an inventory use the enclosed form and return it as soon as possible. In your answer to question 8, please avoid, if possible, a general statement of interest such as "the field of electronics." Our operating methods would be less effective in such a case than if interests were stated more succinctly within the field of electronics.

If you have already mailed in the inventory, please review your answer to question 8 with a view to rephrasing it if your answer is not specific. Incidentally, as these interests change from time to time, we invite you to notify us as soon as possible. We suggest that in the case of very large companies whose combined company-wide technical interests cannot be stated in other than broad terms, the major technical interests of one or a few divisions of the company be cited as most important. We will then, in effect, work only with these divisions until the member company wishes to make a change. In such cases, the names of appropriate people within these divisions should be sent to ARAC as direct contacts rather than (or in addition to) head-office people.

Please note that the enclosed materials describe one ARAC service that was not explained in detail at the March 21 meeting. This service involves the provision of engineering information on current company problems. The Associate Director of Engineering or a member of his staff will visit each of the member companies, particularly their technical people, for a face-to-face discussion of current technical problems. He will then follow through

with this service as described in the attached materials. This service can then be continued on a phone-and-correspondence basis. In the meantime, until he visits your company, you may utilize this service on a phone-and-correspondence basis. Experience so far with several firms visited indicates that this service will be quite productive.

Please take special note of the Scientific and Managerial programs outlined in the enclosed memoranda. We are hopeful that both of these types of services will prove to be highly productive. They will require, however, close working relationships between appropriate company and ARAC personnel.

It is evident that the ARAC services described in these materials are focused on current and short-term technical and managerial problems of member companies. It is less likely that a significant breakthrough in new products, processes and materials will result from these services than one designed to aid the member companies' planning for the longer run, for instance out to five or more years. We are currently working on the design of such a service, and members of ARAC will be visiting you in the near future to get your ideas on this. We are setting an outside target date of late June (at the evaluation meeting mentioned above) for firming up the design of this service and getting it underway in the second quarter. In the meantime, our respective organizations will have time to learn more about each other through operation of the services described in the enclosed memoranda which will serve for the present as our operating manual.

AEROSPACE RESEARCH APPLICATIONS CENTER  
INDIANA UNIVERSITY FOUNDATION  
BLOOMINGTON, INDIANA

ARAC OPERATIONS

Technical Library Service

Collection

For the present, the basic collection of materials in the ARAC library will consist of the following UNCLASSIFIED series of primary research reports deposited by the NASA, Office of Scientific and Technical Information. As this collection is augmented, notices will go out to member companies.

Technical Reports

These are written by research personnel of NASA prime contractors and are prepared in compliance with legal contract terms.

Technical Notes

These are written by NASA research personnel who have been assigned to perform basic research at various NASA installations.

Technical Reprints

These are reports of both primary and secondary research which have been prepared by or for government agencies other than NASA. Reprint rights have been acquired by NASA because the subject is directly related to some phase of aerospace research.

Secondary Reports

The following series of secondary reports have also been deposited by NASA, Office of Scientific and Technical Information, in the ARAC library.

Conference Proceedings

These reports have been compiled and published by NASA to make

available information presented at conferences sponsored by NASA alone, or jointly with other organizations, both government and private.

#### State of the Art Reports

These are reports which summarize the basic theory or current developments in limited subject areas. They are prepared by private and governmental research personnel and may be found in all published series except Conference Proceedings.

#### Technical Translations

These are reports of foreign research, primarily USSR, which have been published in general publications in a foreign language. NASA has acquired translations of these reports, or had them translated by commercial translating services, for republication.

#### Miscellaneous

These materials consist of reviews, handbooks, dictionaries, etc. published by NASA primarily for use by their personnel. (None have been made available to ARAC to date.)

#### Flash Sheets

These reports of innovations in products, materials, and processes with suggested industrial applications are prepared by NASA personnel at the various NASA regional centers. A separate ARAC service provides procedures for the use of Flash Sheets.

To supplement the materials listed above which have been deposited by NASA in the ARAC library, the library staff will consult and borrow materials from the Indiana University Libraries. In addition, the ARAC library will purchase various materials required to aid its staff and member company personnel to use NASA materials effectively.



### ARAC Publications

ARAC plans to publish Industrial Application Reports, Conference Proceedings, Abstracts, Bibliographies, etc. Copies of these will be in the library. A separate ARAC service provides procedures for use of Industrial Applications Reports and Flash Sheet Abstracts.

### Indexes

The current indexes to NASA and general aerospace information which are published for NASA are "Scientific and Technical Aerospace Reports" (preceded by "Technical Publications Announcements 1915-1962"); and "International Aerospace Abstracts." The ARAC library will place current subscriptions for these publications upon receipt of the enclosed request designating a member company addressee. These will be forwarded direct from ARAC to the member company.

ARAC will not have access to CLASSIFIED materials.

### ARAC LIBRARY SERVICE

The ARAC library collection will be a reference collection available to member company personnel during normal working hours. Use of these materials by others will be limited to prevent interference with the library's primary mission. A copy of any item in the ARAC library will be secured for company members on request, except for general trade publications, subject to availability and compliance with copyright laws.

### Operating Procedures

The following procedures will provide the most satisfactory method of operation to expedite library service.

Stating the Question - The member company should state its question in terms to be found in the NASA, "Guide to Annual Subject Index for Technical

Publications Announcements." The question should be stated as precisely as possible. In addition the following should be stated: (1) Scope of the question in terms of literature and time, (2) Type of report desired, (3) Date report required, (4) Special instructions,

The company may write or telephone its question to the ARAC library. The library will make a search and render a report. If the question is an involved one, this report will be a preliminary report which may be used by the company to define the question in more precise terms. After review of the report, an additional search and final report may be requested.

To help define the problem exactly or to evaluate a final report, the member company may call for a conference. This conference would bring together the company's representative, the ARAC library literature specialist, and, if appropriate, a member of the University's science or business school faculty. After consultation a new search may be requested to secure additional or allied information by submitting a more refined question.

To supplement this service ARAC will have access to the resources of various NASA agencies, the Indiana University Computer Center, and the data processing contractor to NASA (Documentation, Inc.). When conditions permit the use of the University Computer Center in the operation of an automatic information retrieval system, an announcement will be sent to member companies explaining the procedures to be followed.

The above description of ARAC Library Operations is summarized in the following diagram. All correspondence involving ARAC Library Operations should be sent to: Nevin W. Raber, Technical Librarian, Aerospace Research Applications Center, Indiana University Foundation, Bloomington, Indiana.

## REFERENCE QUESTIONS

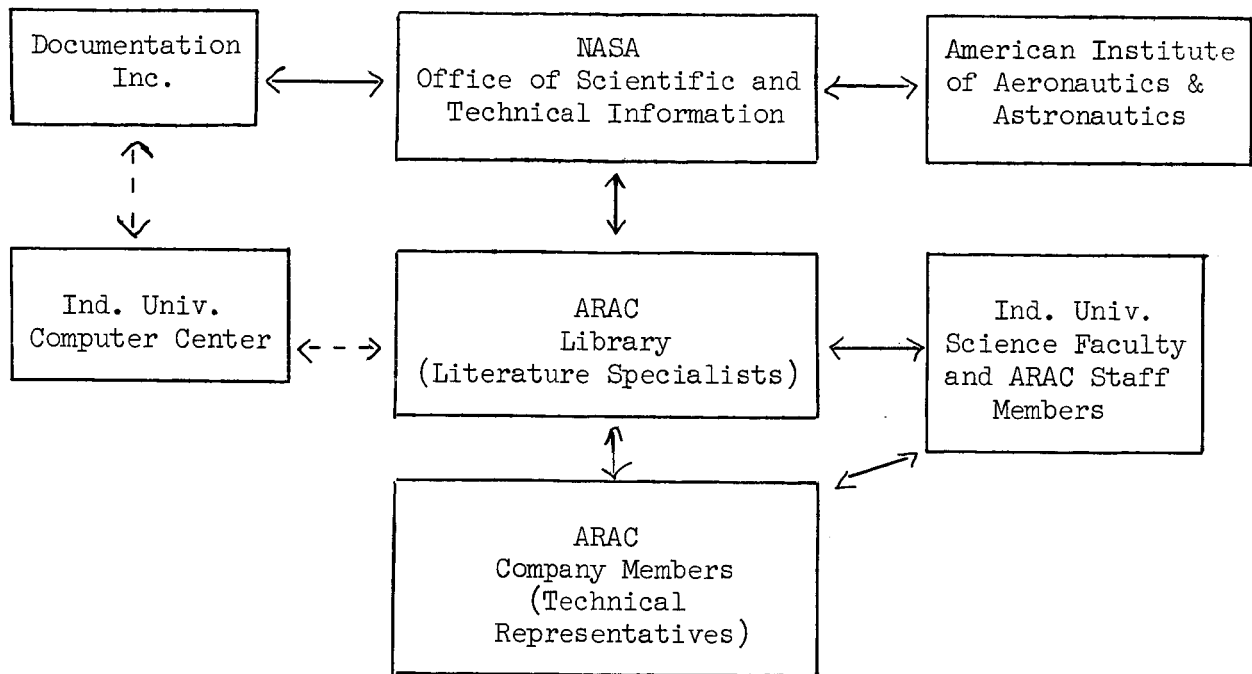
In order to make the desired information search adequate to the members' needs and utilize the time of the literature specialists to gain maximum benefits, the following factors should be included in all questions referred to the library.

1. An exact definition of the problem stated in precise terms.
2. Scope of the search to be performed.  
    Literature limits  
    Time limits
3. Type of report desired.
4. Date report required.
5. Special instructions.

Obviously these points are self limiting (e.g. scope of search vs. date required).

# ARAC LIBRARY OPERATIONS

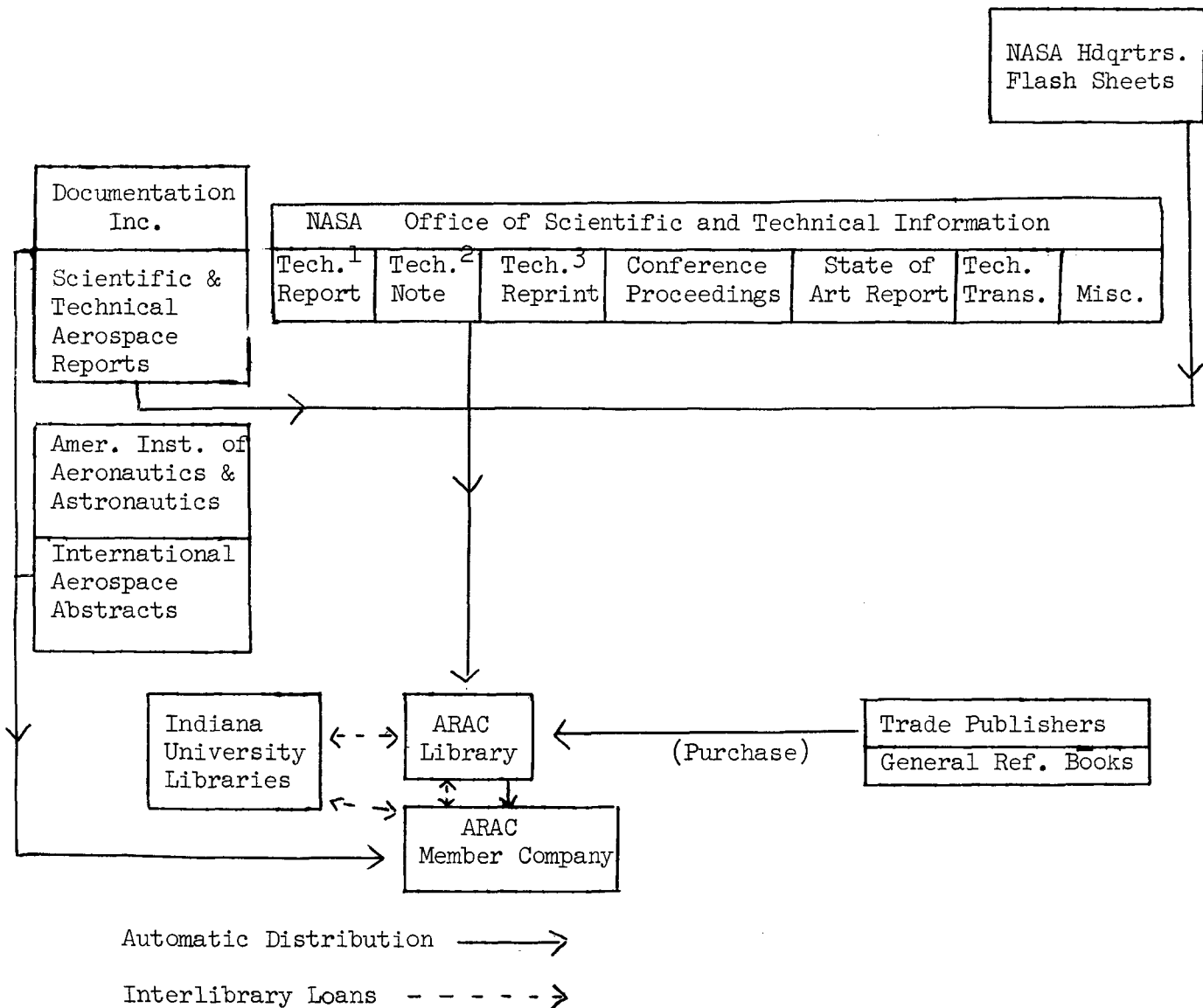
## Reference Service



----- Support as required

# ARAC LIBRARY OPERATIONS

## Materials Acquisitions



### Notes:

1. Produced by NASA prime contractors.
2. Produced by NASA facility personnel.
3. Produced by Non-NASA government agencies.
4. Documentation, Inc. and American Institute of Aeronautics & Astronautics are data processing contractors of NASA, OSTI.
5. ARAC Library will act as a procurement office to secure materials needed for member's permanent file from NASA.

AEROSPACE RESEARCH APPLICATIONS CENTER  
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BLOOMINGTON, INDIANA

ARAC OPERATIONS  
INDUSTRIAL APPLICATIONS SERVICE

Utilization of Flash Sheets

Flash Sheets

NASA Flash Sheets are reports of innovations made by scientists and engineers employed at NASA Regional Centers, such as the Marshall Space Flight Center at Huntsville, Alabama, or by scientists and engineers at NASA prime contractors. The law requires NASA prime contractors to divulge innovations occurring in the execution of contracts.

Innovations are defined as, "A means of accomplishing a work objective either more effectively than before, or for the first time. The term includes the development, invention, discovery, modification or new use of a device, process, material, system, or technique."

NASA Processing of Flash Sheets

Flash sheets are written up on a special form by an Industrial Applications Office at each of the nine regional centers of NASA. Each office employs a chief and senior engineers of various types who spend all their time working up Flash Sheets. Some of the innovations reported are covered by patents or patents pending, others not.

The Flash Sheets are sent by the regional centers to the Industrial Applications Office of NASA in Washington where they are cleared for classified (secret) material and the patent situation checked out. Only non-classified Flash Sheets are available to ARAC and its member companies.

ARAC Operations Utilizing Flash Sheets (Flash Sheet Service):

As they are received by ARAC, Flash Sheets are indexed by member company major technical interests. Hence it is most important that member companies keep ARAC well informed on a continuing basis of their anticipated major technical interests over the next two years.

Flash Sheets are also indexed by the NASA library materials indexing method (See ARAC OPERATIONS - LIBRARY SERVICE).

A periodic listing of all Flash Sheets received by ARAC will be sent to all member companies. This listing will show (non-cumulatively), the identifying number, description title, and suggested industrial applications reported on the Flash Sheets.

ARAC staff engineers, with the help of University science faculty members, will screen the Flash Sheets against member company technical interests and reports. Flash Sheets so screened will be abstracted. Copies of all Flash Sheet Abstracts will be kept on file in the ARAC library (See ARAC OPERATIONS - LIBRARY SERVICE).

Member companies may also request abstracts of Flash Sheets on any item in the periodic Flash Sheet listing that interests them and on which they do not automatically receive a Flash Sheet abstract.

Member companies may pursue further their interests in particular Flash Sheets by visiting ARAC for a depth study of original Flash Sheets, at which time they may pursue further their other interests developed through the use of other ARAC services.

ARAC OPERATIONS - Industrial Applications Reports:

From time to time ARAC will send to member companies Industrial Applications Reports. These reports will contain an explanation of ideas for

commercial applications generated by teams of ARAC engineers, literature specialists, and faculty members from the University science departments. Often these reports will be the result of ideas generated by such teams in their study of NASA Flash Sheets. These reports will be kept on file in the ARAC Library (See ARAC OPERATIONS - LIBRARY SERVICE)..

#### ARAC Consulting Service

As in the case of a Flash Sheet Abstract, a member company may pursue its interests in a particular Industrial Applications Report by further correspondence and if desired a visit to ARAC where a meeting with the ARAC team members who worked up the report will be held.

Additional interest in an Industrial Applications Report requiring extended time in further research or time away from the University (at the member company) may be served by a private consulting arrangement between the company and team members.

#### Flash Sheet Panel Discussions:

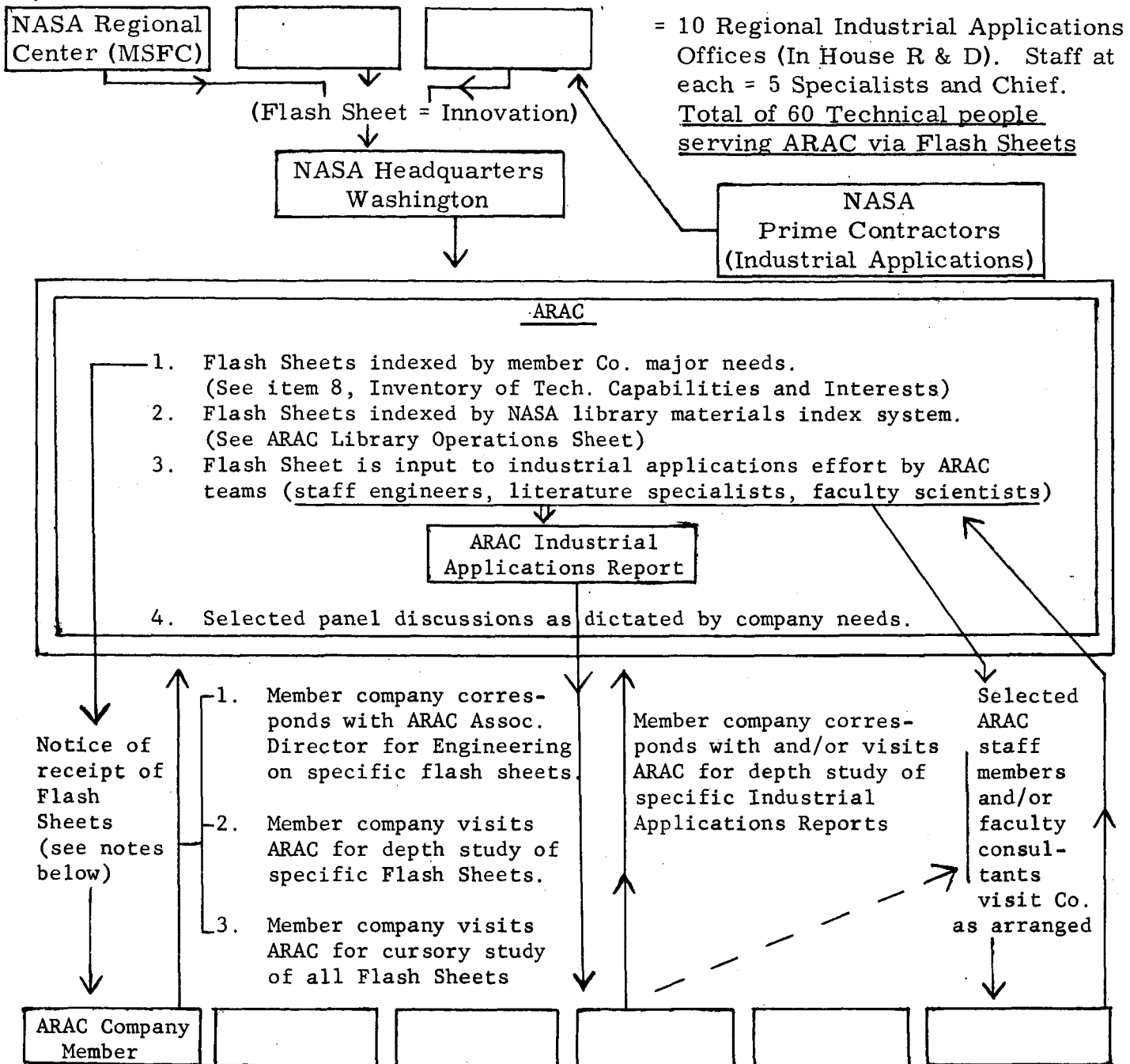
From time to time, collections of Flash Sheets on particular subjects of general interest to a number of member companies may warrant the use of a panel discussion at ARAC. These panel discussions may center on the needs of a single company or may involve participants from several interested member companies. Selected faculty members from Indiana and other universities, and other recognized authorities on the subject may be involved in the various discussions.

All of the above procedures involving NASA Flash Sheets are summarized in the following diagram. Correspondence on these ARAC Services should be directed to Dr. Howard L. Timms, Associate Director for Engineering, Aerospace Research Applications Center, Indiana University Foundation, Bloomington, Indiana.



# ARAC OPERATIONS - INDUSTRIAL APPLICATIONS

## Utilization of NASA Flash Sheets



- (1) Periodic listing of all Flash Sheets by identification no., title, and suggested commercial applications sent to all member companies.
- (2) Abstracts of Flash Sheets associated with member company major technical needs sent to company.
- (3) General Note: Visits to ARAC by company specialists should be planned so as to utilize all ARAC services during a visit, that is: Library Service, Flash Sheet Service, Industrial Applications Report Service, and Individual Faculty Consulting Service.

AEROSPACE RESEARCH APPLICATIONS CENTER  
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BLOOMINGTON, INDIANA

ARAC OPERATIONS

Engineering Service on Current Problems

Member companies will have current engineering problems that ARAC may help solve through its knowledge of current technical developments at the various regional centers of NASA. Most of these problems will be concerned with current products, processes, and materials, whereas the engineering service of ARAC involving the use of NASA Flash Sheets, especially the Industrial Applications Report, is focused on new products, processes, and materials (See ARAC OPERATIONS - INDUSTRIAL APPLICATIONS SERVICE).

Staff engineers of ARAC will spend time at NASA regional centers for the purpose of getting acquainted with current research projects. Likewise, ARAC staff engineers will visit member companies to learn current technical problems. Out of such visits may come a matching of current NASA research findings to current company problems.

As an example of this service, ARAC staff engineers learned in a visit to one NASA regional center that they were in the late stage of research in leak detection techniques. Obviously this subject is of great importance in design, building, testing, and operation of space vehicles. Many companies have similar problems in connection with production, testing, and operation of products involving a vacuum or inert gas atmosphere. Solutions to these company problems may be found in current NASA research findings.

When a "match" of NASA research and member company current problems is achieved, ARAC staff engineers will aid the member company in formulating specific technical questions about their problems, then transmit the questions

to the appropriate person in NASA. We will not be able to handle questions of a broad nature, or general questions, in this ARAC service. The reason for this is obvious. For instance, if a question on leak detection were framed as, "We want to know all about leak detection," we could only reply that the inquiry will be answered when a NASA Technical Report is available (see ARAC OPERATIONS - LIBRARY SERVICE).

Member companies may transmit current technical problems by phone or in writing to ARAC, not awaiting a visit by an ARAC staff engineer. In such cases, the question should be made specific, but enough background and related information should be provided to insure proper interpretation by the ARAC engineer.

All correspondence on this ARAC Engineering Service on current problems should be directed to Dr. Howard L. Timms, Associate Director for Engineering, Aerospace Research Applications Center, Indiana University, Bloomington, Indiana.

AEROSPACE RESEARCH APPLICATIONS CENTER  
INDIANA UNIVERSITY FOUNDATION  
BLOOMINGTON, INDIANA

ARAC OPERATIONS

Scientific Programs

ARAC Internal Operations

As indicated in the descriptions of other services of ARAC, the services of the faculty of Indiana University science departments are available in internal ARAC operations. These are repeated here. Faculty scientists participate as required in:

1. Indexing Flash Sheets against member company technical interests.
2. Preparation of Flash Sheet Abstracts.
3. Preparation of Industrial Applications Reports.
4. Consultation to ARAC literature specialists.

Science Faculty Service Direct to Member Companies

1. Industrial Applications Reports: As indicated in the description of the use of these reports (see ARAC OPERATIONS -- INDUSTRIAL APPLICATIONS SERVICE), faculty scientists who participate in the preparation of these reports will be available for consultation to member companies as arranged between the individual company and scientist. This service is outside normal ARAC operations and is initiated by the member company. All such arrangements must be made by first contacting the Associate Director for Science, Mr. Paul Klinge.
2. Continuing Faculty - Company Relationships: Individual member companies may arrange continuing relationships with individual science faculty members for consultation, joint research, etc. These arrangements are outside normal ARAC operations and should be arranged through Mr. Paul Klinge.

### Science Faculty Panels and Seminars

ARAC will arrange from time to time science panel discussions and seminars involving one or more member companies and other participants, including faculty members of Indiana University science departments. These science panels on subjects of general interest to one or more member companies may be initiated at the request of member companies, or by ARAC with invitations to member companies to participate. Topics for these panel discussions will arise in the various ARAC operations such as Flash Sheets, Library Service, Industrial Applications Reports, and research being conducted by faculty scientists, as well as in member company activity.

### Weekly Science Bulletin Service

A bulletin covering notices of university scientific events such as seminars, conferences, etc., that are regularly held at the Bloomington campus and the Indianapolis Medical campus will be mailed weekly to all member companies. Company representatives are invited to attend events of interest to them.

### Scientific Publications Service

1. Science Brochures: These publications describe major efforts of science faculty members currently under way. They provide a means of acquainting people with the research interests and activities of the various science departments of Indiana University. As they are published, these brochures will be sent to member companies.
2. Research Grants: The Indiana University Foundation issues regularly an information bulletin listing research grants received. These bulletins will be mailed to all member companies. They provide a means of acquainting interested people of upcoming research projects some of which may be of interest to member companies.

### Joint Research Projects

One of the features of many NASA and Department of Defense research projects is a team effort involving a company and a university. Mr. Klinge will assist in the preparation of proposals for such projects by interested member companies.

### Research Grants

Member company technical interests may sometimes require research in an area for which company facilities are inadequate or on a topic for which its staff are not trained. In such cases, university scientists and facilities may be engaged through a research grant. Inquiries concerning this service should be addressed to Mr. Paul Klinge.

### University Fellowships

To keep an adequate flow of skilled personnel, many companies have discovered the value of assisting education by providing fellowships for graduate students in science. In many cases, the research performed by the student in his graduate program is valuable to the company. Also, having the student available to the company for summer work during his graduate program is found useful. Member companies interested in such arrangements should contact Mr. Paul Klinge.

### Short Courses

Member companies may wish to send selected individuals to short courses provided by the university in specialized subjects, e.g., statistical methods in biological research, etc. Inquiries on this service should be sent to Mr. Paul Klinge,

#### Seminars at Member Companies

Every effort will be made to arrange, on request, seminars on scientific subjects at member companies, utilizing I. U. scientists. These may be single lectures, a regular series, or occasional programs. This service is outside normal ARAC operations and arrangements should be made by contacting Mr. Paul Klinge.

#### Other Arrangements

Various special arrangements between member companies and the university science departments may be made. We solicit suggestions and ideas. For example, one company has a scientist on its payroll who holds a faculty appointment. His teaching load is partial. The company assumes his full salary.

AEROSPACE RESEARCH APPLICATIONS CENTER  
INDIANA UNIVERSITY FOUNDATION  
BLOOMINGTON, INDIANA

ARAC OPERATIONS

Managerial and Related Programs

Continuing Planning Service

ARAC will provide service on a continuing basis to managements of member companies in developing operating plans and procedures at the member companies, and between them and ARAC, directed toward more effective long range planning for new markets and products to fill these markets, thence back into the identification of technical interests involved. ARAC operations will then be conducted to stress serving these interests.

Under the direction of the Associate Director for Development, Dr. William L. Haeberle, faculty members of the Graduate School of Business will review new managerial techniques and processes developed as a result of NASA's operations and where considered applicable will report these to member companies.

Quarterly Meetings

Quarterly meetings of top management personnel of the member companies will be held in part to review ARAC operating experiences, and in part to consider new managerial developments.

Current Management Problems Service

Member companies are invited to make requests in writing or by telephone to Dr. Haeberle for assistance on specific managerial problems. He will forward materials if they are directly available or where required, visit member company offices.



The following procedure is recommended:

1. Representatives of member companies should write or call Dr. Haeberle relative to request for information on managerial and related problems.
2. Dr. Haeberle will provide information either by telephone, memorandum or by forwarding printed materials, or where required prepare special reports.
3. Upon request and with appropriate lead time, Dr. Haeberle and/or members of his staff, will visit member company offices to discuss their managerial and related problems.

#### Management Panels and Seminars

ARAC will arrange for panel discussions and seminars on selected subjects of interest to management. Specialized personnel will be provided by ARAC for these activities. For instance, some companies may be interested in PERT. A panel discussion or seminar involving a day's program on this subject would be arranged. Experts in the subject would be obtained from the faculty of the Graduate School of Business, other universities, and industry as required.

This service may be initiated at the request of one of more member companies or at the suggestion of ARAC. The topics of these panels and seminars may cut across the entire field of management interest--top management, functional management (marketing, finance, production, accounting, etc.), management training and development, personnel practices, etc.

When more extensive managerial consulting services are required, Dr. Haeberle will assist companies in identifying personnel who may meet their

requirements, but individual consulting arrangements should then be worked out between company representatives and the consultants involved.

#### Management Publications

ARAC member companies will regularly receive publications of the Graduate School of Business such as Business Horizons, The Indiana Business Review, and pertinent publications, including research reports on managerial subjects, of the Bureau of Business Research.

These procedures will be reviewed at a later date and revised as required. All correspondence involving ARAC Managerial and Related Programs should be sent to Dr. William L. Haeberle, Associate Director for Development, Aerospace Research Applications Center, Indiana University Foundation, Bloomington, Indiana.